CMHC
Canada Mortgage and Housing Corporation

SCHL
Société canadienne d'hypothèques et de logement

Tumbler Ridge District Heating Study: Summary of Findings

Research Report

August 1983

Canada

CMHC File No. 5840-4-1

TUMBLER RIDGE

DISTRICT HEATING STUDY:

SUMMARY OF FINDINGS

Prepared for
The Technical Research Division
Policy Development and Research Sector
of
Canada Mortgage and Housing Corporation

by

Cogeneration Associates Limited
151 Bloor St. West
Suite 650
Toronto, Ontario.
M5S 1S4

Principal Consultant: A. Juchymenko, P. Eng.
CMHC Project Manager: D. H. Minty, P. Eng.

This project was funded by Energy, Mines and Resources Canada but the views expressed are the personal views of the author and no responsibility for them should be attributed to EMR or CMHC.

TUMBLER RIDGE DISTRICT HEATING ABSTRACT

District heating involves the concept of using inexpensive available fuels or industrial waste heat to supply economic space heating and domestic hot water.

This report summarizes the technical and economic factors involved in previous studies of district heating for Tumbler Ridge, and concludes that the development of a district heating system is technically feasible and financially viable due to the availability of inexpensive waste coal as fuel for this system.

Acknowledgement

The funding for this study was provided by the Department of Energy, Mines and Resources, Canada.

The guidance and review of this report was granted by courtesy of the Project Managers:

Mr. D.H. Minty - Canada Mortgage and Housing Corporation

Mr. T. Hedley - Ministry of Energy, Mines and Petroleum Resources, Vancouver, B.C.

The members of the Advisory Committee for Energy Related Studies are:

Mr. G. Hiscox, Chairman	- CMHC, B.C. Regional Office
Mr. P. Favot	- CMHC, National Office, Ottawa
Mr. G. Armstrong	- Energy, Mines and Resources, Ottawa
Mr. P. Walsh	- Commissioner, Tumbler Ridge, B.C.
Mr. G. Paget	- Ministry of Municipal Affairs, Victoria, B.C.
Mr. T. Hedley	- Ministry of Energy, Mines & Petroleum Resources, B.C.
Mr. P. Lumb	- Energy, Mines and Resources, Ottawa

The findings presented in this report are based on the opinions of Cogeneration Associates Limited and do not represent the policy or position of the Advisory Committee, CMHC or EMR.

TABLE OF CONTENTS

Title		Page
(i)	EXECUTIVE SUMMARY	(iii)
1.0	INTRODUCTION	1-1
2.0	TOWN OF TUMBLER RIDGE	2-1
3.0	ENERGY REQUIREMENTS	3-1
4.0	ENERGY SUPPLY OPTION	4-1
5.0	DISTRICT HEATING SYSTEM	5-1
	5.1 Heating Plant	5-1
	5.2 Hot Water Distribution System	5-6
	5.3 Customer Equipment	5-8
6.0	CAPITAL COSTS	6-1
	6.1 Cost of Heating Plant	6-1
	6.2 Cost of Distribution System	6-5
	6.3 Cost of Customer Equipment	6-5
7.0	OPERATING COSTS	7-1
	7.1 Labour Cost	7-1
	7.2 Fuel Cost	7-1
	7.3 Electricity Cost	7-3
	7.4 Cost of Materials	7-3
8.0	FINANCIAL ANALYSIS	8-1
9.0	INSTITUTIONAL CONSIDERATIONS	9-1
10.0	SUMMARY OF CONCLUSIONS	10-1
11.0	RECOMMENDATIONS	11-1

APPENDIX A
APPENDIX B
APPENDIX C
APPENDIX D

LIST OF TABLES AND FIGURES

Table		Page
Table 3.1	SMOOTHED HOUSING SCHEDULE	3-3
Table 3.2	RESIDENTIAL HEATING DEMAND	3-4
Table 3.3	COMMERCIAL/INSTITUTIONAL HEATING DEMAND	3-5
Table 3.4	TOTAL HEATING DEMAND	3-6
Table 5.0	TOTAL ENERGY DELIVERED BY HEATING PLANT	5-5
Table 5.1	PIPE FOR DISTRIBUTION SYSTEM	5-7
Table 6.0	CAPITAL COST SUMMARY - STEAM HEATING PLANT (With Cogeneration Option)	6-2
Table 6.1	CAPITAL LAYOUT SCHEDULE (With Cogeneration Option)	6-3
Table 6.2	CAPITAL COST SUMMARY - HOT WATER HEATING PLANT (No Cogeneration Option)	6-4
Table 7.1	COAL REQUIREMENTS	7-2
Table 7.2	SUMMARY OF COST DATA (With Cogeneration Option)	7-4
Table 7.3	SUMMARY OF COST DATA (No Cogeneration Option)	7-5
Table 8.0	ESTIMATED ESCALATION RATES	8-2
Table 8.1	SUMMARY OF CASH FLOW ANALYSIS	8-3

EXECUTIVE SUMMARY

This report summarizes the work performed and data collected by several organizations relating to the supply of energy for the planned mining townsite of Tumbler Ridge, B.C.

1. In August of 1981, Cogeneration Associates Limited (CAL) was engaged by Canada ortgage and Housing Corporation to '...carry out research to investigate the technical and economic feasibility of providing space heating and domestic hot water..' for this community. The funding for this study was provided by the Department of Energy, Mines and Resources, Canada.

2. In October of 1982, a preliminary report by CAL indicated that district heating was economically feasible for this community. It was the most promising option, given the obvious availability of coal as fuel.

3. In January of 1982, the Advisory Committee of Energy Related Studies for Tumbler Ridge decided to verify the findings of the earlier study and to prepare a design concept for the district heating system, with the provision that the heating plant could be retrofitted to a cogeneration option. Intercontinental Engineering Ltd. (INTEG) of Vancouver was engaged for this work.

4. INTEG prepared a conceptual design utilizing the steam boiler system. The estimated capital cost for the total system was $14,707,000. The internal rate of return on this investment was 22.6%. Further work was done by CAL to investigate the possibility of utilizing a hot oil system instead of steam. It was found that if the heating plant were to be designed around this system, the total capital cost would be reduced to $12,588,000., and the internal rate of return would increase to 28.5%. However, because of the time constraint, INTEG was unable to incorporate this lower capital cost in their analysis. It has been included in this report.

This planned community will be developed over a period of five years (1982 - 1986) and is expected to house about 5,000 people by 1986, requiring about 2,500 dwelling units and a commercial centre to serve the town. The estimated total heating requirement for the town is as follows:

	Heat Consumption ,000 GJ	Heating Plant Capacity MW
1982	86.9	10
1983	168.4	20
1984	211.6	30
1985	235.2	30
1986	252.3	30
1987	254.5	30
1988	259.0	30
1989	263.5	30
1990	267.9	30

The quality of housing units is assumed to meet CMHC's 'Measures'** specifications.

By 1986 the operating cost of the heating plant would be as follows:

	1982 $	%
Fuel -	$235,300.	30.1%
Labour -	$300,000.	38.5%
Materials -	$ 76,400.	10.0%
Electricity -	$107,000.	13.6%
Trucking -	$ 61,400.	7.8%
	$780,100.	100.0%

* The revenue after 1986 would be $2,573,941. in 1982 dollars.

(Calculated from consumption of 252,300 GJ/year of energy sold at $10.21/GJ, assuming a natural gas price of 23¢/m^3 or $6.50/ MCF)

** Measures for Energy Conservation in New Buildings, 1978
NRC #16574

5. The design of the district heating system is based on circulating hot water at 120°C delivered to the users, who would install equipment suitable for removing energy from the system for their heating and domestic hot water requirements. The return water to the heating plant would be at 55°C. The hot water distribution system would be factory insulated steel pipe buried directly in the soil at a depth of about 500 mm.

6. The new town of Tumbler Ridge is an ideal site for demonstrating an effective technology for reducing the cost of energy to a town. Costs would be reduced mainly because the town is a green field project, with construction and other conditions being favourable, for example:

   .1 Pipes for the distribution system can be laid when streets are excavated for the installation of other utilities;

   .2 Location of the heating plant can be centered to reduce pipe cost and losses;

   .3 New dwelling units being built can be designed to accommodate the use of hot water as energy for heating;

   .4 Fuel for the system is inexpensive, local and plentiful.

   It is the absence of these very conditions which drive up the costs of installing a new system in an existing town.

7. In developing district heating at Tumbler Ridge, several institutional and structural constraints must be overcome.

   .1 The first major problem was encountered in attitudes. The development of this technology would be the responsibility of the town. Tumbler Ridge would have to obtain additional funding to build this system, take the responsibility for supervising its construction, and later, operate it as a utility to provide heating to its residents as it does roads, sewers, electricity, etc. The prospect of this additional responsibility, together with the idea of an untried technology in a remote, mountainous Canadian setting, made the town commissioner and his staff apprehensive of the project. The enthusiasm which is required to pioneer and promote a new technology and its application was

absent from the officials at Tumbler Ridge. Although the attitude of the B.C. provincial energy authorities was positive. when the commissioner submitted the project to the provincial Cabinet Committee on Coal Development for funding, it was rejected. This is unfortunate, for it would have been the first full scale European type district heating project in North America, with far reaching benefits to the development of district heating in Canada.

.2 A second matter was the fact that the consultants had difficulty in obtaining Canadian sources of acceptable equipment. Such items as hot water heaters, fan coil units, pipe fittings, hot water boilers, etc. were not available from established suppliers in the residential heating field. New suppliers had to be found and encouraged to enter a new field and to consider new equipment and devices. In many cases, European items for such a project were available, but they are not acceptable because of their high prices, performance, appearance, etc. If district heating systems are to be developed in Canada, more Canadian suppliers would have to be actively involved in bringing Canadian equipment up to the standards and versatility of European equipment.

.3 The third problem of a major magnitude which became clearly obvious during this study is one of conceptual critetia for engineers. In Canada, there are no established standards, guidelines and practices for consultants to follow in designing a district heating system. Therefore, each consultant relies on whatever expertise he has gained in the utility or industrial field. This tends to prolong the analysis of the project, and involves a considerable variance in capital costs.

Accordingly, it is important that standards and guidelines be developed in order to streamline the design of district heating systems, as it is done in many European countries. Some of the European standards could be integrated here, while others would have to be developed to utilize our existing practices and fabricating facilities. This can be accomplished by a working committee created for this purpose, initiated and funded by the federal government.

1.0 INTRODUCTION

In Canada, the choice of fuel and heating systems for homes, offices and factories is largely dictated by economics. Over the past fifty years, the fuels which have been used for space heating and domestic hot water have been wood, coal, fuel oil, natural gas and electricity. Fuel oil has been the most popular fuel, followed by natural gas.

At this time, the price of fuel oil is increasing, and both the provincial and federal governments are discouraging its use for space heating, while encouraging the use of lower grade fuels which are still plentiful. When considering the use of natural gas, not only its escalation price, but the cost of pipelines and the process plant must be taken into account, which precludes its use for remote communities.

Because coal is plentiful and relatively inexpensive in some parts of Canada, its use as a heating fuel would be preferred, provided that it could be burned efficiently without it being detrimental to the environment. This can be done effectively in larger boiler plants. The best method of distributing energy produced from coal in a central station to homes, businesses and institutions, is to change its energy form to hot water, steam or electricity. The most efficient and least costly medium is hot water. Such distribution of heating energy is referred to as district heating. This system has been developed and widely used in the Scandinavian countries for many years. In general, district heating systems fired with natural gas or oil are not financially competitive with natural gas distribution systems and individual heating systems. However, if the fuel is coal, wood by-products, or municipal waste, then district heating is competitive.

At Tumbler Ridge, a small community being planned for the development of coal resources in northeastern British Columbia, district heating appears to be economically feasible. The town is to be built over a period of five years (1982 - 1986) and will contain about 5,000 people. Besides having 2,500 dwelling units, the town will have a central core comprising shopping facilities, medical services, municipal and government offices, a recreation centre, hotels, schools, etc.

The sources of energy for this community are natural gas, electricity and coal. Coal mined locally could be burned in a central station and the hot water produced could be distributed to the users via a pipe distribution system. The customers could be billed for the heat consumed at a rate established by some reasonable critetia based on the cost of operating the system and the cost of other, competitive sources of energy.

In August of 1981, Cogeneration Associates Limited (CAL) was engaged by Canada Mortgage and Housing Corporation to "...carry out research to investigate the technical and economic feasibility of providing space heating and domestic hot water.." for this community. The funding for this study was provided by the Department of Energy, Mines and Resources, Canada.

In October of 1981, a preliminary report was prepared by CAL to be discussed by the Advisory Committee for Energy Related Studies concerning the New Townsite of Tumbler Ridge, B.C. The committee was established by the Corporation to assist in the decision process. This report indicates that district heating was technically and economically attractive, and that the most promising fuel option for the town would be coal, inasmuch as coal would be readily available and inexpensive in this remote coal town.

In January of 1982, the Committee recommended that a more thorough investigation be undertaken by a Vancouver engineering consulting firm to verify the findings of the earlier study by CAL, and to propose a design concept for the district heating system. The funding for this work came from the District of Tumbler Ridge, the province of British Columbia and the federal government. After an open competition by five Vancouver consulting firms, the contract was awarded to Intercontinental Engineering Ltd. (INTEG).

Much of the data relating to the energy requirements of the town and the distribution system used by INTEG was obtained from the initial study by CAL. INTEG prepared a conceptual design for the heating plant, modified the distribution system to incorporate the updated townsite plan, and compiled a capital cost estimate for the total project.

The officials of Tumbler Ridge made a presentation of the proposed district heating scheme to the Cabinet Committee on Coal Development. They requested that the government guarantee a loan to implement the construction and operation of this scheme. The committee discussed the energy options, and decided against the request by the District of Tumbler Ridge.

This report describes the proposed district heating project, summarizes the technical and economic factors affecting the possible development of the project, draws conclusions, and makes recommendations from the collected data.

All the figures used in Design A of this report are taken from INTEG's reports to the District of Tumbler Ridge, entitled:

'District Heating System - Review of Cost and Feasibility', March 1982
'District Heating System - Feasibility Study - Supplementary Report' May 1982

Other data pertinent to district heating at Tumbler Ridge comes from reports by CAL, entitled:

'Analysis of Integrated Energy Systems and Feasibility of District Heating for Tumbler Ridge, B.C.', October 1981

'Notes for Meeting - Advisory Committee for Energy Related Studies at Tumbler Ridge', December 14, 1981

2.0 TOWN OF TUMBLER RIDGE

The proposed town of Tumbler Ridge is to be located (by air) about 90 kilometres southwest of Dawson Creek, or about 700 kilometres northeast of Vancouver. The townsite will be situated on a series of terraces overlooking the confluence of the Marray and Wolverine Rivers and Flatbed Creek. This town is being built primarily to house the employees and families of several newly developed coal mines operating in the vicinity. The population of Tumbler Ridge is expected to reach about 5,600 by 1986. Housing will be varied; single family houses, townhouses and apartments.

Tumbler Ridge is an independent community which will eventually be fully self-governing. At present, the responsibility for planning, development and supervision of the site is performed by an appointed commissioner and a small staff of managers. As for technical and supervisory functions, they depend on the consulting community for personnel and advice.

Because the town is a green field project, a district heating scheme was one of the options considered by CAL during a preliminary energy supply evaluation for the town. The availability of coal as fuel for district heating at this site showed that this system could be economically attractive for the purpose of supplying space heating and domestic hot water for the community. Further work by INTEG of Vancouver was undertaken to confirm the earlier estimates by CAL and to define the design parameters for the system.

The construction and development of Tumbler Ridge is divided into phases. Phase 1 entails work on the town core, while Phases 11 to 1X refer to work on the subdivisions. Phases 1, 11 and 111 are scheduled to be completed by 1983, and the other phases are to be undertaken between 1983 - 1986, with Phase 1X completed by 1986.

3.0 ENERGY REQUIREMENTS

The town requires two types of energy. First, there is the electrical requirement for motors, lights, communication equipment, etc. Secondly, thermal energy is required to heat space and to produce the domestic hot water (DHW). With a cogeneration station, both of these types of energy could be obtained from the same fuel. This system allows the maximum utilization of equipment with a very high operating efficiency. However, cogeneration requires a higher initial investment than would a system designed for district heating only. Electricity rates are relatively low, therefore, it is all but certain that electrical power would be supplied to Tumbler Ridge by B.C. Hydro, while the thermal requirements would be fulfilled by electricity, natural gas or coal.

The size of the thermal load of this community is determined by the number, size and quality of the living units and the demand for domestic hot water. (The planned number of living units to be constructed over the period of 1982-1986 and the size of the commercial and institutional buildings are shown in Table 3.1) The maximum energy requirements of the housing units is assumed to be in accordance with the NRC 'Measures'* specifications. (The residential heating loads are shown in Table 3.2 and are based on heat loss calculations by Mr. David Eyre of the Saskatchewan Research Council.** The Commercial/Institutional demand is given in Table 3.3)

The heating load comprises space heating and domestic hot water. The domestic hot water demand for residential and commercial use represents 26% in 1982 and a projected 22% in 1986. Because the supply of DHW makes such a significant contribution to the load factor, it is an important function of the district heating system. Therefore, when space heating is not required, DHW will provide the necessary cash flow for the district heating utility without interfering with the maintenance of the system or staff vacations.

* 'Measures for Energy Conservation in New Buildings', 1978, NRC #16574

** 'Energy-Efficient New Housing at Tumbler Ridge, B.C., Second Report: Heat Loss and Economic Analysis', October 1981

By 1986, when the town would be essentially developed, its total heat demand is estimated to be 252,300 GJ/year. This load would increase with time, but at a slower rate, and by 1990 it is projected to reach 268,100 GJ/year.

It is to be noted that the heat demand estimates for the town were calculated by the Saskatchewan Research Council (SRC) and revised several times since CAL's first report of October 1981. The figures in this report were obtained from SRC in March 1982. Since that time, these figures have again been revised upward by over 20,000 GJ/year but they are not used in this analysis. However, with an increase in the load demand the district heating system becomes even more economically attractive.

TABLE 3.1

SMOOTHED HOUSING SCHEDULE

(incremental)

TUMBLER RIDGE: BASE CASE

October 28, 1981

Year	Phase*	Detached	Attached	Multiple	Mobile	Commercial & Institutional (m^2)	Total Heat Required GJ/h
1982	I,II,III	292	50	505	164	8,000	37
1983	IV, V, X	252	39	345	124	17,100	64
1984	VI, VII	189	27	0	78	10,000	72
1985	VIII	84	8	0	21	9,200	92
1986	IX	50	4	0	0	9,000	97
1987		24	0	0	0		
1988		44	2	0	0		
1989		43	3	0	0		
1990		43	2	0	1		
1991		0	0	0	0		
TOTAL		1021	135	850	388	53,300	

NOTES: 1.* All Commercial & Institutional buildings are in phase I.

2. Heating plant stages 1, 2 and 3 relate to 1982, 1983 and 1985 respectively.

3. Construction after 1986 has been taken into account in the preliminary DH design concept.

4. The total heat required takes into account the line losses and an 80% diversity factor.

Source: "Review of Cost and Feasibility", Integ, Table 4-1

TABLE 3.2

TUMBLER RIDGE

RESIDENTIAL HEATING DEMAND

'000 GJ/year

	Space Heating	Domestic Hot Water	Total
1982	54.6	22.0	76.6
1983	97.3	38.7	136.0
1984	120.8	45.6	166.4
1985	129.7	48.3	178.0
1986	133.6	49.6	183.2
1987	135.4	50.2	185.6
1988	138.8	51.2	190.0
1989	142.3	52.3	194.6
1990	145.7	53.3	199.0

Source: "Review of Cost and Feasibility", Integ, Tables 4-3, 4-4

TABLE 3.3

TUMBLER RIDGE

COMMERCIAL/INSTITUTIONAL HEATING DEMAND

'000 GJ/year

	Space Heating	Domestic Hot Water	Total
1982	9.6	0.8	10.4
1983	30.2	2.4	32.6
1984	42.2	3.3	45.5
1985	53.3	4.2	57.5
1986	64.1	5.0	69.1
1987	64.1	5.0	69.1
1988	64.1	5.0	69.1
1989	64.1	5.0	69.1
1990	64.1	5.0	69.1

Source: "Review of Cost and Feasibility", Integ, Table 4-5

TABLE 3.4

TUMBLER RIDGE

TOTAL HEATING DEMAND

'000 GJ/year

	Residential	Commercial	Total
1982	76.6	10.4	87.0
1983	136.0	32.6	168.6
1984	166.4	45.5	211.9
1985	178.0	57.5	235.5
1986	183.2	69.1	252.3
1987	185.6	69.1	254.7
1988	190.0	69.1	259.1
1989	194.6	69.1	263.5
1990	199.0	69.1	268.1

Source: "Review of Cost and Feasibility", Integ, Tables 3-2, 3-3.

4.0 ENERGY SUPPLY OPTIONS

All commonly used fuels can be made available to Tumbler Ridge at market prices.

Natural gas is available in the vicinity and can be piped to the town from either the transmission line or from local, independent wells located within a radius of about 40 km from the site. Since a power line will be required to supply electricity from B.C. Hydro, a heavier line can be provided at a relatively small increase in cost, one large enough to carry the increased load for space heating.

Locally mined coal will also be available. Both marketable coal and coal waste are suitable for heating energy. However, coal is not a convenient fuel for domestic use, and must be confined to larger boilers which are economical and better adapted to pollution control.

Oil and propane can also be used for heating, but they are excluded from consideration here because of their high cost. These two fuels should only be considered for use as supplementary or stand-by fuels, and would be stored at the site.

Since the town of Tumbler Ridge is being built to house workers for the two developing coal mines operated by Quintette Coal Corporation and Teck Corporation, the supply of coal at reasonable prices is within the control of these companies. For these reasons, the fuel selected for district heating for this town is coal, with fuel oil or propane as a stand-by fuel.

5.0 DISTRICT HEATING SYSTEM

A district heating system comprises three major parts: the heating plant, distribution piping and user equipment. Each of these sub-systems has several options as to equipment and operating requirements. However, for optimal operation, such design criteria as the working fluid temperature and the required temperature drop (ΔT) determine the type of equipment which is to be used.

The choice of the working temperature is dictated by the source of heat, cost of pipe, and distribution losses. In Europe, where hot water systems are popular, the supply temperatures vary from 90°C to 180°C. In cases where the source of heat is a cogeneration station, the temperature is in the order of 95°C. When fuel fired boilers supply a district heating system directly, 120°C is a common supply temperature.

In the initial report by CAL, a cogeneration station was investigated which would supply both electricity and heat simultaneously to the town. The maximum design working water temperature was 95°C, while later, INTEG conducted their analysis without the cogeneration option, and used a maximum supply temperature of 120°C. The temperature of the return water was 55°C for both studies.

The size of pipe and the losses depend on the working temperature. The size of pipe is smaller for 120°C water than it is for 95°C, but the heat losses are higher for a higher temperature. If the pipe size was optimized, the smaller pipe surface area would offset the higher temperature. However, in this case the pipe size for 120°C water was larger than a good design would call for. In the actual design, this discrepancy would have been rectified.

5.1 Heating Plant

In order to deliver 120°C water from the heating plant to the distribution system, the heating plant can produce this hot water either directly in boilers, or it can produce low pressure steam, and then provide hot water close to 120°C via heat exchangers.

Another system receiving attention for the production of heat is the use of an organic fluid (oil) in the coil tube boilers operating at atmospheric pressure. This oil is heated to 300°C and is circulated through heat exchangers to heat the district heating water for distribution to users. The advantage of this system over steam or hot water is that it allows the operation of the heating plant without the obligatory number of operators normally required by the Operating Engineers Act. The savings in operating costs are sufficiently large to encourage engineers to consider this system. In British Columbia, there are many such systems in the sawmills and other wood oriented industries. The impetus for their use is low operating costs for personnel. However, these boilers usually operate at a lower conversion efficiency than can be achieved with fire tube or water tube boilers.

The type of fuel to be used is determined by its availability and its cost. Coal fired units cost more than five times that of oil fired units, but the cost of coal is much lower than oil. Therefore, a trade-off must be made between the capital cost and the operating cost. INTEG decided to use all coal fired units except for one 5 MW oil fired unit which was to be used in the first year, and then stored for stand-by or emergency duty.

According to their terms of reference, INTEG considered only systems which could be retrofitted for cogeneration in the future. Therefore, since oil filled systems cannot easily be converted to cogeneration, INTEG considered only steam boilers capable of producing high pressure steam to operate turbines for the production of electricity.

However, as the feasibility study progressed and capital costs for a high pressure steam system were substantially higher than the costs provided by CAL in October 1981, INTEG reviewed their design, and

concluded that for a small system such as that required at Tumbler Ridge, a cogeneration option greatly increased the level of investment, and the complexity of the system increased accordingly. Therefore, a simple heating system designed for automatic operation would in this case be preferable, especially as B.C. Hydro would be providing electricity to the town at relatively low rates. Cogeneration is best utilized when the supply of electricity is unstable, insecure, or too costly.

Due to constraints of time, INTEG was unable to incorporate into the economic analysis the hot oil circulating system proposed by K.C.I. Mechanical Inc. INTEG noted this option in a letter to Tumbler Ridge dated April 13, 1982. This report investigates that system further in the capital cost section and the financial analysis section.

The size of the heating station required to satisfy the heating demand of the town, plus the line losses, are given in Table 5.0. This load varies from 95,000 GJ/year in 1982 to 274,200 GJ/year in 1986.

In order to meet this increasing demand, the following boiler capacity is required:

Year	Incremental	Total
1982	2 - 5 MW	10 MW
1983	1 -10 MW	20 MW
1984	1 -10 MW	30 MW

The fundamental difference in approach to the heating plant between the steam system proposed by INTEG and the oil heating system suggested by K.C.I. Mechanical is reflected in the capital cost. Steam boilers, which are vertical, require a building of about 16 m in height, while the building proposed by K.C.I. would be only 6 m high, making it less costly.

Other differences between the two approaches are to be found in the electrical supply. In total, the electrical demand at the plant in 1985 is estimated to be 611.8 kW. This load can be supplied from

B.C. Hydro's system without an expensive transformer station because Hydro will supply up to 650 kW, 3 phase, 600 V at Schedule 1200. Therefore, the cost of a transformer and switching equipment could be eliminated.

The most important difference, however, is in the operating cost. A plant equipped with boilers using circulating oil does not require operating engineers, except for one, third class engineer to be in charge in B.C. However, when the plant is equipped with steam boilers, a full complement of operating engineers is required. Therefore, the operating cost of a steam plant is much higher. There are other items besides these which are different in the two approaches, reflecting the difference in cost. The ability to burn municipal waste in the K.C.I. boilers adds a positive feature to that system, although no allowance was made for this feature in the operating costs.

TABLE 5.0

TUMBLER RIDGE

TOTAL ENERGY DELIVERED BY THE HEATING PLANT

'000 GJ/year

Year	Heating Consumption	Thermal Losses	Total Plant Delivery
1982	87.0	8.0	95.0
1983	168.6	14.8	183.4
1984	211.9	18.8	230.7
1985	235.5	20.7	256.2
1986	252.3	21.9	274.2
1987	254.7	22.2	276.9
1988	259.1	22.8	281.9
1989	263.5	23.4	286.9
1990	268.1	23.7	291.8

5.2 Hot Water Distribution System

The hot water distribution system was designed to supply space heating and domestic hot water for all dwellings at Tumbler Ridge. The pipe layout of this system is shown in Figure 5.0. The supply and return pipes will be buried side by side under the boulevards or the sidewalks. It is proposed that the district heating plant be located near the intersection of Road #10 and Road #40, in the southeast corner of the town centre.

Factory insulated steel pipe, using rigid polyurethane insulation, protected on the outside by a high density polyethylene jacket was specified for this installation. The pipe is designed for direct burial at a depth of about 500 mm. The total length of pipe proposed is given in Table 5.1.

The size of the pipe has not been optimized. The sizes are essentially the same as those used by both CAL and INTEG, however CAL used 95°C water, while INTEG used 120°C water. At 95°C the calculations were made with a flow of 1.5 m/second, while at 120°C this becomes only 0.91 m/second, which is well below the acceptable practice for district heating. By reducing the size of pipe to accommodate a flow rate of 1.5 m/second or even higher, the cost of the pipe, fittings, expansion devices and construction can be substantially reduced.

TABLE 5.1

TUMBLER RIDGE
PIPE FOR DISTRIBUTION SYSTEM

DISTRIBUTION SYSTEM DESIGN PARAMETERS

Max Supply Temp.	-	120°C
Max Return Temp.	-	55°C
Design Pressure	-	1.033×10^3 kPa
Hydrostatic Test Pressure	-	1.55×10^3 kPa
Max flow velocity	-	1.52 m/s
Min flow velocity	-	0.91 m/s
Peak Capacity	-	1982 - 10 MW 1985 onwards - 27 MW

DITCH LENGTHS

DIA.	STAGE 1 (metres)	STAGE 2 (metres)	STAGE 3 (metres)
400	474	0	0
300	400	0	0
250	206	0	0
200	1926	1873	937
150	1074	1417	708
100	1030	960	480
80	1020	1077	538
60	1585	1673	836
50	500	600	300
40	500	600	300
25	10263	11202	5601
	18978	19402	9700

NOTE: Length of pipe is twice the ditch length.

5.3 Customer Equipment

Although the responsibility for the design and specification of customer equipment rests with the developer and the builder, assistance was offered in specifying the type, size, and suppliers for such equipment, and was accepted. Technical personnel from CMHC, Tumbler Ridge, and D.W. Thomson Consultants of Vancouver investigated these features and the cost of installing the various systems available and suitable for space and domestic hot water heating. Two suppliers were located who were prepared to supply fan coil units suitable for space heating for residential dwellings, at prices competitive with gas fired, hot air systems and central electric furnaces. The heating equipment for commercial and institutional buildings posed no problem since there are several suppliers of such equipment in Canada.

A Canadian supplier of domestic hot water tanks and heat exhanger units was located in Mississauga. However, the price for the limited production required for Tumbler Ridge was approximately 75% higher than that of gas fired, hot water tanks. This is partly due to the time limitation in obtaining the quotes, and partly to the small production runs that would be necessary to supply the project.

A preliminary investigation was conducted to determine if baseboard units would be suitable for space heating. This equipment would appear to be satisfactory, but there is some concern of passing 120°C water directly through the baseboard. However, small heat exchangers or special control valves could be used to overcome the safety problems. Baseboard units would lower the cost of installation of equipment, suitable for use with a district heating system, to a figure lower than the cost of conventional gas furnaces.

The D.W. Thomson report indicates that the cost of installing space and domestic hot water equipment, suitable for use with a district heating system, as compared to equipment normally used with gas fired, individual systems, would be approximately 1.8 million dollars less.

6.0 CAPITAL COSTS

Capital cost figures compiled in this report are taken from Integ's "Review of Cost and Feasibility" report of March 1982 and their supplementary report of May 1982. They are divided into costs for:

(a) Heating Plant
(b) Distribution System
(c) Customer Equipment

6.1 Cost of Heating Plant

As discussed in section 5.0, there are two approaches to supplying heat for a district heating system at Tumbler Ridge. In their calculations, Integ assumed a steam producing system which could be retrofitted to generate electricity at a later date. This steam system, which is referred to as a "cogeneration option" will cost $7,514,000 and is shown in Table 6.0. The schedule of this capital layout is shown in Table 6.1 indicating a high initial expenditure in 1982 at 43.3% of the total cost, and decreasing to 33.3% in 1983 and 23.4% in 1985. The capital layout is heaviest at the beginning of the project due to engineering, site preparation, building, and installation of services. The later costs will be for additional boilers and their installation.

An alternative to steam is a hot oil system priced at $4,830,000 entitled "no cogeneration option". This includes the cost of the heating plant as quoted by K.C.I. Mechanical Inc. at $4,430,000 and $400,000 for engineering and contingency. This expenditure would also be distributed over the duration of the project. Table 6.2 shows the total capital cost of such a system at $12,588,000 which is well below the $14,707,000 required for the steam operated system.

TABLE 6.0

TUMBLER RIDGE

CAPITAL COST SUMMARY

STEAM HEATING PLANT

(Design A - With Cogeneration Option)

		(1982) $
1.0	Site Clearance and Improvements	170,867
2.0	Buildings and Structures	1,129,260
3.0	Coal and Ash Handling	479,000
4.0	Oil Storage and Handling	77,000
5.0	Boiler (Oil Fired)	258,000
6.0	Boilers (Coal Fired)	2,731,000
7.0	Piping (Mechanical)	418,500
8.0	Piping (Distribution System)	6,672,000
9.0	Ducts and Supports	inc. in 6.0
10.0	Stack	inc. in 6.0
11.0	Miscellaneous Mechanical	466,400
12.0	Electrical System	819,850
13.0	Instrumentation (Includes Flowmeters)	541,000
14.0	Engineering I.P.M.	820,000
15.0	Testing and Radiog	125,000
		14,707,877

Source: Integ, May 1982, Table 2-1

TABLE 6.1

TUMBLER RIDGE

CAPITAL LAYOUT SCHEDULE

(Design A - With Cogeneration Option)

($1982)

Year	Plant	Distribution	Total	%
1982	3,259,000	3,114,000	6,373,000	43.3
1983	2,517,000	2,374,000	4,891,000	33.3
1984	nil	nil	nil	nil
1985	1,738,000	1,705,000	3,443,000	23.4
	7,514,000	7,193,000	14,707,000	100 %

Source: INTEG, May 1982, Table 2-2

TABLE 6.2

TUMBLER RIDGE

CAPITAL COST SUMMARY*

HOT WATER HEATING PLANT

(Design B - No Cogeneration Option)

		$ 1982
1.0	Heating Plant**	4,430,000
2.0	Distribution System***	6,672,000
3.0	Instrumentation	541,000
4.0	Engineering	820,000
5.0	Testing, etc.	125.000
		12,588,000

* Other than item #1 the costs are the same as in Table 6.0.

** Heating Plant Cost Estimate is obtained from KCI Mechanical Inc. as a Turn-key project.

*** No optimization for the distribution system was undertaken.

6.2 Cost of Distribution System

The capital cost of the distribution system is estimated by INTEG to be $7,193,000. This figure includes all costs associated with installing the system such as engineering, ditching, welding, back filling, testing, etc. It also includes the cost of flow and energy meters.

It should be noted that the size of piping and its route has not been optimized. Essentially, because of the time constraint, INTEG used calculations made earlier by CAL which were done for 95°C supply water rather than 120°C, as assumed by INTEG. With the higher water temperatures, the size of pipe should be much smaller. Therefore, it is estimated that the capital cost of $7,193,000 can be substantially reduced. A reduction of 20% would be reasonable. However, the INTEG figure is used for this report.

6.3 Cost of Customer Equipment

Investigations conducted by CMHC's Technical Research Division, and work done by D.W. Thomson Consultants of Vancouver for the government of British Columbia in April 1982, indicates that the equipment used for district heating in residences and commercial buildings costs about the same or less than competing systems such as the gas fired, forced air furnace system or the central electrical heating system. Therefore, the costs associated with customer equipment at Tumbler Ridge do not adversely affect the economics of the system and will not be introduced into the financial analysis.

7.0 OPERATING COSTS

The operating costs consist of the cost of labour to operate the plant and the distribution system, the cost of maintenance material, fuel costs and electricity costs.

7.1 Labour Cost

When a heating plant produces steam, there is a prescribed complement of operating personnel required to be in attendance at the plant at all times. Integ estimates the labour cost for such a plant to be $506,200. per year. (See Table 7.2)
However, when boilers use circulating oil for heating, the number of operators is reduced, and the labour cost is reduced to $300,000. per year. (See Table 7.3)

7.2 Fuel Cost

The fuel cost for this report is assumed to be $0.858/GJ. This price is calculated for mixed coal consisting of 80% waste coal and 20% marketable coal. (Fuel use by year is given in Table 7.1.)

During the course of the study, several coal prices were obtained from the coal mines in the region. The best price was $30./tonne quoted by B.P. Coal Co. This company has a mine about 72 km from Tumbler Ridge, which it operates to supply coal for export through the port of Vancouver. The quantities were small, but they had hoped to develop a larger export market. However, the cost of shipping through Vancouver and the limited market forced this company to terminate their operation as of February 1982. They were willing to sell their inventory of about 30,000 tonnes to Tumbler Ridge. This supply would suffice to operate the district heating system until 1985 when coal from the Quintette mine would be available.

Quintette Coal Ltd. quoted a price of $50/tonne for marketable quality coal and $25/tonne for a mixture of marketable and waste coal. When the calorific value of these coals is taken into account the prices become:

Marketable Coal - $1.63/GJ
Mixed Coal - $0.853/GJ

The effect of using mixed coal is that coal trucking quantities increase, and ash disposal increases.

In addition to coal, the heating plant would require small quantities of oil or propane as starting fuels, but mostly as stand-by fuels. Oil is significant only in the first year of operation when part of the heating load would be supplied from oil fired boilers.

TABLE 7.1
TUMBLER RIDGE
COAL REQUIREMENTS

	Revenue 000 GJ	Coal-Mixed 000 Tonne	Coal Marketable 000 Tonne
1982	86.9	0	0
1983	168.4	15.56	7.40
1984	211.6	19.59	9.31
1985	235.2	21.74	10.34
1986	252.1	23.27	11.07
1987	254.5	23.50	11.18
1988	259.0	23.93	11.38
1989	263.5	24.35	11.58
1990	267.9	24.77	11.78

Source: Integ Supplementary Report, May 1982, Table 6-1 and 6-4

7.3 Electricity Cost

Electricity is required to power the pumps and operate fans and material handling equipment. This power is supplied by B.C. Hydro under their Schedule 1200. Electricity costs are projected to increase from $24,700 in 1982 to $107,200 after 1985, using the 1982 rates as per Schedule 1200.

7.4 Cost of Materials

Materials required to operate the proposed system such as chemicals, paint, cleaning fluids, lubricants, etc., are estimated to cost $33,100 in 1982, increasing to $76,400 after 1985.

TABLE 7.2

TUMBLER RIDGE

SUMMARY OF HEAT CONSUMPTION AND COST DATA

(Design A - With Cogeneration Option)

	Heat Consumption ,000GJ	Oil Consump. ,000GJ	Coal Consump. ,000GJ	Aux Elec ,000$	Labour ,000$	Materials ,000$	Coal ,000Te	Capital ,000$
1982	86.9	95.0	-	24.7	459.3	33.1	0	7176
1983	168.4	-	183.4	62.2	506.2	58.7	15.56	5543
1984	211.6	-	230.7	62.2	506.2	58.7	19.59	-
1985	235.2	-	256.2	107.2	506.2	76.4	21.74	3828
1986	252.3	-	274.2	107.2	506.2	76.4	23.27	-
1987	254.5	-	276.9	107.2	506.2	76.4	23.50	-
1988	259.0	-	281.9	107.2	506.2	76.4	23.93	-
1989	263.5	-	286.9	107.2	506.2	76.4	24.35	-
1990	267.9	-	291.8	107.2	506.2	76.4	24.77	-

(& onwards)

Source: INTEG, Supplementary Report, May 1982, Table 6-4

TABLE 7.3

TUMBLER RIDGE

SUMMARY OF HEAT CONSUMPTION AND COST DATA

(Design B - No Cogeneration Option)

	Heat Consumption ,000 GJ	Oil Consump. ,000 GJ	Coal Consump. ,000 GJ	Elect. ,000$	Labour ,000$	Materials ,000$	Trucking ,000 /tonne	Capital ,000$
1982	86.9	95.0	-	24.7	300	33.1	0	5314
1983	168.4	-	183.4	62.2	300	58.7	15.56	4363
1984	211.6	-	230.7	62.2	300	58.7	19.59	-
1985	235.2	-	256.2	107.2	300	76.4	21.74	2911
1986	252.3	-	274.2	107.2	300	76.4	23.27	-
1987	254.5	-	276.9	107.2	300	76.4	23.50	-
1988	259.0	-	281.9	107.2	300	76.4	23.93	-
1989	263.5	-	286.9	107.2	300	76.4	24.35	-
1990	267.9	-	291.8	107.2	300	76.4	24.77	-

(& onwards)

Source: INTEG, Supplementary Report, May 1982

8.0 FINANCIAL ANALYSIS

In order to establish the feasibility of district heating at Tumbler Ridge and to compare the design with a cogeneration option (Design 'A') with that of a simple district heating system without a cogeneration option (Design 'B'), a discounted cash flow analysis was undertaken. The data used in this analysis is summarized in Tables 7.2 and 7.3.

Since the projected life of the project was assumed to be operational until the year 2015, a set of escalation indices was assumed. (These are given in Table 8.0.) Capital costs and operating costs were established in Section 6.0 and 7.0. Revenue, which depends on the sale of energy from the district heating system, is calculated by multiplying the amount of energy sold by $10.21/GJ. This energy price was established by INTEG and is related to the cost of electricity for space heating at Tumbler Ridge.

It is understood from the B.C. Utilities Commission that Northland Utilities (B.C.) Ltd. are negotiating with Tumbler Ridge and Quintette to establish the price of gas. It is likely that its cost to the users will be in excess of $6./GJ. At 65% seasonal efficiency, the effective energy cost will be approximately $10./GJ, which is in the same range as the cost of electricity.

A summary of the cash flow analyses for the two design alternatives is given in Table 8.1, and the computer printout sheet can be found in Appendix A.

The initial rate of return for a simple system without a cogeneration option is 28.5%, whereas it is 22.6% for a steam system with a cogeneration option. The higher capital and operating costs of the steam system reduce the rate of return of the project. This is because it involves potential cogeneration. No electricity (hence no electrical revenue) would be produced in the immediate future.

TABLE 8.0

TUMBLER RIDGE

ESTIMATED ESCALATION RATES

Parameters	% Escalation
Inflation Rate	10
Energy selling price	12
Oil price 1982-1985	15
Oil price 1986 onward	12
Coal price	12
Electricity price	11.5
Labour	11
Materials	10
Trucking	11
Interest	15

Other Parameters used in Financial Analysis:

Energy selling price	$ 10.21 /GJ
Oil selling price	$ 6.389/GJ
Coal price	$ 0.853/GJ
Trucking price	$ 2.64/tonne

TABLE 8.1

TUMBLER RIDGE

SUMMARY OF CASH FLOW ANALYSES

		Design 'A' Cogeneration Option	Design 'B' No Cogeneration Option
(a)	Present Value of Cash Flow	$7,554,000	$13,758,000
(b)	Internal Rate of Return	22.61%	28.51%
(c)	Profitability Index $\frac{\text{p.v. cash flow}}{\text{p.v. capital}}$	0.51	1.23
(d)	Simple Pay-back Period	8.3 yrs.	6.68 yrs.

9.0 INSTITUTIONAL CONSIDERATIONS

It was assumed that the proposed district heating system would be owned and operated by the town of Tumbler Ridge, because it is unlikely that a private operator could be found who would invest in such a project. Therefore, it was proposed that the town raise the necessary funds, supervise the installation of the system, and later operate it as a Section within its Department of Works.

Because the proposed system requires additional funds, staff, and management expertise, the present officials at Tumbler Ridge were not receptive to the proposed district heating system. There are no similar installations in Canada at this time, therefore they did not wish to be involved with a pilot project or a demonstration installation with a high capital layout for a system which has not been proven in North America. They preferred a traditional system such as natural gas or electricity for space heating. Attempts to show that the district heating system would be efficient and economical were met with skepticism and doubt. Therefore, without a strong pioneering attitude or a substantial financial incentive, the project could not proceed.

This fear of an unknown technology to be installed in a remote community is the hardest hurdle to overcome. Since there are no such systems operating anywhere in Canada, as there are in Europe, it was difficult to show its viability to the town's developers. This was, in fact, a unique opportunity to demonstrate and begin a new technology in a green field situation in Canada.

A second constraint is related to the limited number of Canadian manufacturers of heating equipment, proven fabricated pipe, fittings, boilers, etc. which would be suitable for district heating systems at competitive prices. Equipment from Europe for residential and commercial installations is unacceptable in Canada due to its standards, performance, appearance, and the high prices associated with import duty and a devalued dollar. Therefore, a new industry would have to be developed if district heating is to be an acceptable technology in Canada, and for this to occur, we need suitable demonstration sites. The proposed Tumbler Ridge district heating project would have been an ideal opportunity to conduct a full scale demonstration of European type district heating in Canada.

The third problem of a major magnitude which became clearly obvious during this study is one of conceptual criteria for engineers. In Canada, there are no established standards, guidelines and practices for consultants to follow in designing a district heating system. Therefore, each consultant relies on whatever expertise he has gained in the utility or industrial field. This tends to prolong the analysis of the project and results in high capital costs.

For example, costly utility stations produce steam at high pressures to optimize their electricity producing cycles, while a district heating system requires only hot water. If this hot water is produced in a simple and inexpensive plant, the capital cost can be significantly reduced. Operating costs are also lower for hot water plants.

During the course of the conceptual design, the capital costs for the Tumbler Ridge project were reduced from $25,000,000. to $14,707,000. by redesigning the electrical and mechanical circuits and simplifying the plant to suit the district heating requirements. If time had permitted it, this cost could have been reduced even further to $12,588,000. by using oil circulating boilers to produce hot water.

Accordingly, it is important that standards and guidelines be developed in order to streamline the design of district heating systems as it is done in many European countries. Some of these European standards could be implemented here, while others would have to be developed to utilize our existing practices and fabricating facilities. This could be accomplished by a working committee set up for this purpose, initiated and funded by the federal government.

10.0 SUMMARY OF CONCLUSIONS

Based on the work done by CAL and INTEG in determining the feasibility of district heating for Tumbler Ridge, the following conclusions have been reached:

1. Both alternatives are financially viable. However, design 'B' without a cogeneration option, has a better internal rate of return at 28.51% in comparison with 22.61% for design 'A', with a cogeneration option.

2. Capital and operating costs for the heating plant are very dependent upon the type of boilers used for the production of hot water for the distribution system.

3. Steam boilers for design 'A', with a cogeneration option, entail a higher electrical consumption, require larger buildings, and require more operators of a higher qualification than to boilers for design 'B' with no cogeneration option.

4. Optimization of the piping for the distribution system was not undertaken. Pipe sizes were the same for 95°C water as for 120°C water in the distribution system.

5. The officials of Tumbler Ridge were not enthusiastic about providing a district heating service to the town's residents as they do with water, roads, sewers, etc.

6. Lack of standards and proven practices in the design of district heating systems in Canada, necessitates engineers to rely on their own experience of district heating gained in industrial and utility plants.

7. There are very few district heating equipment manufacturers in Canada. In general, equipment available from Europe is not acceptable to Canadian users due to its high price, appearance, standards and performance.

11.0 RECOMMENDATIONS

The conclusions drawn from this report suggest that there are three major hurdles to overcome in the development of district heating at Tumbler Ridge and in Canada in general:

.1 to convince the municipal officials and elected representatives that district heating can be a viable alternative source of energy for space heating and domestic hot water,

.2 to develop a set of standards or guidelines for design engineers to follow when district heating is being considered,

.3 to encourage the development of manufacturing facilities and equipment for the establishment of a district heating supply industry.

Therefore, it is recommended that CMHC, in concert with other federal departments such as Energy, Mines and Resources, Canada Public Works, etc. set up a working committee to develop guidelines and specifications for design parameters for district heating. These parameters should include the following:

1. Plant Design

.1 Type of Boilers
- Steam
- Hot water
- Hot oil
- Other

.2 Electrical Supply

.3 Pump arrangement

2. Distribution System

.1 Type of Pipe
- Insulation
- Gauge
- Length of sections

.2 Pipe connection to Customer Equipment

.3 Fittings
- Insulation
- Length of valves, etc.

.4 Expansion Systems

.5 Leak Detection and Alarm System

3. Customer Equipment

.1 Hydronic system - Radiators

.2 Forced Air Circulation

.3 Space Heating Controls

.4 Domestic Hot Water Systems

.5 Canadian Suppliers

APPENDIX A

Cash Flow Analysis

Calculations

Sample Calculation

Data for Cash Flow Analysis
Reference: Table 7.2
Table 8.0

1. Gross Revenue

Gross Revenue = Energy Sales in GJ/year x energy price

Gross Revenue (1982) = 86,900 x $10.21 = $887,249

2. Total Expenses

Total Expenses = Labour + Fuel Oil Cost + Coal Cost
+ Electricity Cost + Material Cost
+ Transportation Cost

Total Expenses (1982) = $459,300 + (95,000 GJ x $6.389) + (0 x $0.858)
+ $24,700 + $33,100 + (0 x $2.64) = $1,124,055

3. Net Profit

Net Profit = Gross Revenue - Total Expenditure
= $887,249 - $1,124,055 = ($236,806)

CASHFLOW - ,000$ Design "A"

With Cogeneration Option

DATE: 05/27/82

TUMBLER RIDGE

YEAR	GROSS REVENUE	TOTAL EXPENSES	NET PROFIT	CAPITAL INVESTMENTS	CASH FLOW BEFORE TAX	INCOME TAX	CASH FLOW AFTER TAX
1982	887.25	1124.05	(236.81)	7176.00	(7412.81)		(7412.81)
1983	1925.69	917.64	1008.04	6097.30	(5089.26)		(5089.26)
1984	2710.05	1083.82	1626.23		1626.23		1626.23
1985	3373.78	1329.90	2043.88	5095.07	(3051.19)		(3051.19)
1986	4050.15	1509.44	2540.71		2540.71		2540.71
1987	4579.35	1684.00	2895.35		2895.35		2895.35
1988	5219.56	1883.72	3335.84		3335.84		3335.84
1989	5947.47	2107.15	3840.32		3840.32		3840.32
1990	6772.40	2357.00	4415.40		4415.40		4415.40
1991	7585.09	2622.12	4962.97		4962.97		4962.97
1992	8495.30	2917.12	5578.18		5578.18		5578.18
1993	9514.74	3245.39	6269.35		6269.35		6269.35
1994	10656.50	3610.68	7045.82		7045.82		7045.82
1995	11935.28	4017.20	7918.09		7918.09		7918.09
1996	13367.52	4469.58	8897.94		8897.94		8897.94
1997	14971.62	4973.03	9998.59		9998.59		9998.59
1998	16768.21	5533.32	11234.90		11234.90		11234.90
1999	18780.40	6156.88	12623.52		12623.52		12623.52
2000	21034.05	6850.88	14183.17		14183.17		14183.17
2001	23558.13	7623.28	15934.85		15934.85		15934.85
2002	26385.11	8482.97	17902.14		17902.14		17902.14
2003	29551.32	9439.84	20111.48		20111.48		20111.48
2004	33097.48	10504.89	22592.59		22592.59		22592.59
2005	37069.18	11690.38	25378.80		25378.80		25378.80
2006	41517.48	13009.96	28507.52		28507.52		28507.52
2007	46499.58	14478.84	32020.74		32020.74		32020.74
2008	52079.53	16113.95	35965.58		35965.58		35965.58
2009	58329.07	17934.13	40394.94		40394.94		40394.94
2010	65328.56	19960.39	45368.17		45368.17		45368.17
2011	73167.99	22216.10	50951.88		50951.88		50951.88
TOT	655157.85	209847.67	445310.18	18368.37	426941.81		426941.81
PV	35536.74	13195.03	22341.71	14787.51	7554.20		7554.20

TUMBLER RIDGE A1

PROFITABILITY INDICATORS

NET CASH FLOW	(PVAT)	$7554
DCF RATE OF RETURN	(PC.)	22.61
PROFITABILITY INDEX		0.51
PAYOUT (AFTER TAX)		8.30

Design "B"

No Cogeneration Option

DATE: 05/27/82 ,000$

TUMBLER RIDGE B

YEAR	GROSS REVENUE	TOTAL EXPENSES	NET PROFIT	CAPITAL INVESTMENTS	CASH FLOW BEFORE TAX	INCOME TAX	CASH FLOW AFTER TAX
1982	887.25	964.75	(77.51)	5314.00	(5391.51)		(5391.51)
1983	1925.69	688.76	1236.93	4799.30	(3562.37)		(3562.37)
1984	2710.05	830.01	1880.04		1880.04		1880.04
1985	3373.78	1047.90	2325.89	3874.54	(1548.65)		(1548.65)
1986	4050.15	1196.41	2853.73		2853.73		2853.73
1987	4579.35	1336.54	3242.81		3242.81		3242.81
1988	5219.56	1498.04	3721.51		3721.51		3721.51
1989	5947.47	1679.05	4268.43		4268.43		4268.43
1990	6772.40	1881.79	4890.61		4890.61		4890.61
1991	7585.09	2094.62	5490.46		5490.46		5490.46
1992	8495.30	2331.60	6163.70		6163.70		6163.70
1993	9514.74	2595.46	6919.27		6919.27		6919.27
1994	10656.50	2889.27	7767.23		7767.23		7767.23
1995	11935.28	3216.42	8718.86		8718.86		8718.86
1996	13367.52	3580.72	9786.79		9786.79		9786.79
1997	14971.62	3986.40	10985.22		10985.22		10985.22
1998	16768.21	4438.16	12330.06		12330.06		12330.06
1999	18780.40	4941.25	13839.15		13839.15		13839.15
2000	21034.05	5501.53	15532.52		15532.52		15532.52
2001	23558.13	6125.51	17432.63		17432.63		17432.63
2002	26385.11	6820.44	19564.67		19564.67		19564.67
2003	29551.32	7594.43	21956.89		21956.89		21956.89
2004	33097.48	8456.49	24641.00		24641.00		24641.00
2005	37069.18	9416.65	27652.53		27652.53		27652.53
2006	41517.48	10486.13	31031.35		31031.35		31031.35
2007	46499.58	11677.38	34822.19		34822.19		34822.19
2008	52079.53	13004.33	39075.20		39075.20		39075.20
2009	58329.07	14482.45	43846.62		43846.62		43846.62
2010	65328.56	16129.03	49199.53		49199.53		49199.53
2011	73167.99	17963.29	55204.69		55204.69		55204.69
TOT	655157.85	168854.84	486303.01	13987.84	472315.17		472315.17
PV	35536.74	10549.36	24987.38	11229.03	13758.35		13758.35

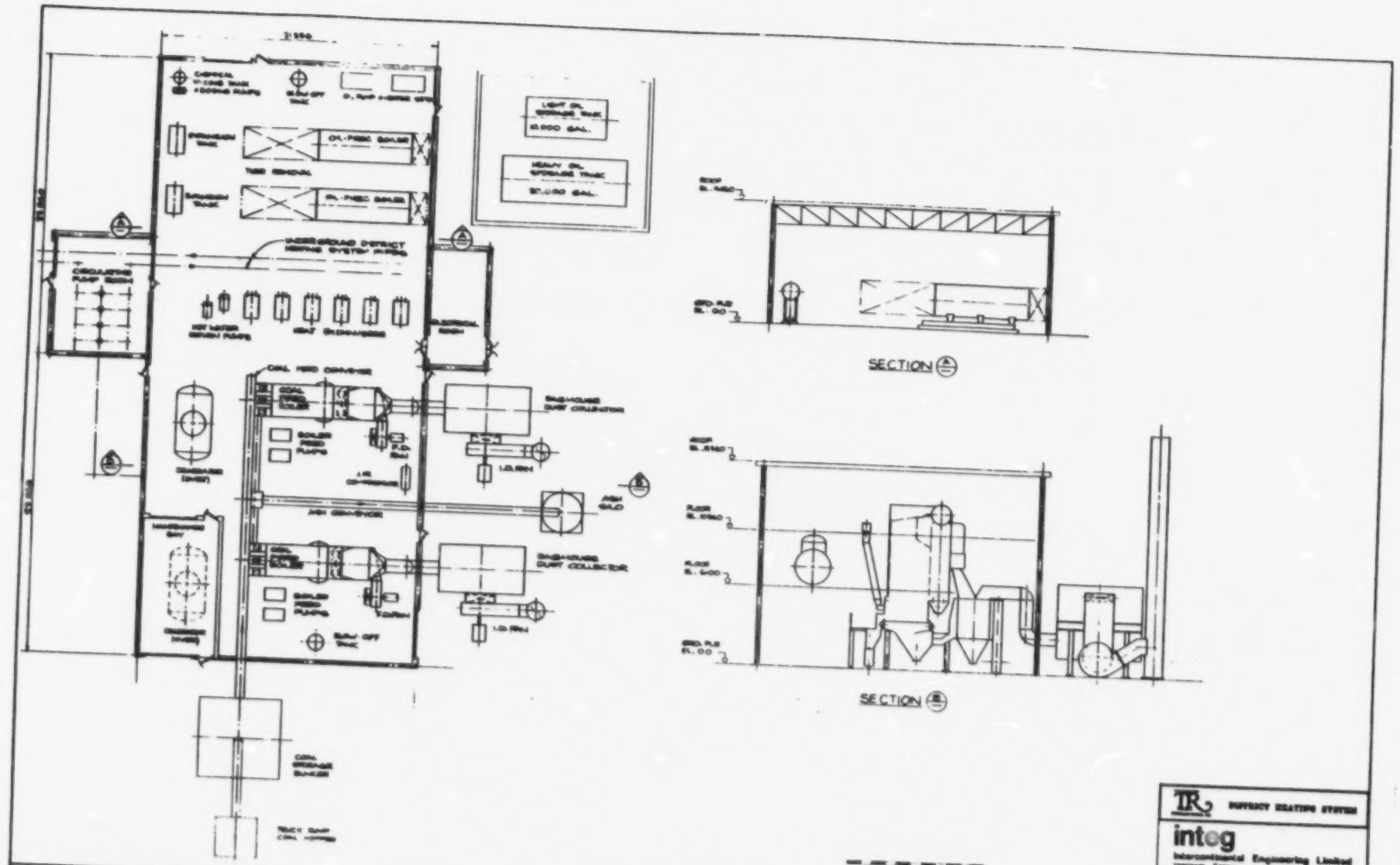
TUMBLER RIDGE B1

PROFITABILITY INDICATORS

NET CASH FLOW	(PVAT)	$13758
DCF RATE OF RETURN	(PC.)	28.51
PROFITABILITY INDEX		1.23
PAYOUT (AFTER TAX)		6.68

APPENDIX B

INTEG's Design Proposal


SECTION
SECTION
SCALE 1:100 METRES
intog
Intercontinental Engineering Limited
CENTRAL HEATING PLANT
GENERAL ARRANGEMENT
D 0211 004 SK 01

Mr. D.H. Minty, P.Eng.
Project Manager
Technical Research Division
Canada Mortgage and Housing Corporation
National Office
Montreal Road
Ottawa, Ontario
K1A 0P7

October 6, 1982

Subject: Tumbler Ridge, B.C. - District Heating

Dear Sir:

We are pleased to submit a report entitled:

" Tumbler Ridge, B.C. District Heating Study - Summary of Findings "

This report describes the proposed district heating project at Tumbler Ridge, B.C., a planned community being built to house the families of miners who would be working and living in this remote town in northeastern British Columbia. It summarizes the technical and economic factors affecting the possible development of the project, draws conclusions, and makes recommendations from the collected data.

The data used in this summary comes from the work performed by our staff and Intercontinental Engineering Ltd. (INTEG) of Vancouver.

Based on the collected data, it appears that a district heating system would be technically feasible and financially viable for Tumbler Ridge. The major factor contributing to this viability is the availability of inexpensive waste coal from the local mines as fuel.

We wish to thank the Corporation for inviting us to participate in this study, and for the co-operation which the Division staff has given us in the course of compiling this report.

Yours truly,

A. Jur.

Alex Dychymenko, P.Eng.

APPENDIX C

Proposal by K.C.I. Mechanical Inc.

KCI MECHANICAL
design manufacture install

p.o. box 386
oakville, ontario
416·842·4744

January 26th, 1982

Cogeneration Ltd.,
151 Bloor St.W.,
Toronto, Ontario
M5S 1S4

Subject - Tumbler Ridge

Dear Alex;

Further to our discussion of last week we have made several alterations to our origional layout both subsequent to our conversation and due to a new intensive study of sulphur contamination.

In the latter we find that the tube treatment in similair relatively low temperature hot water boilers is just not standing up despite word we had to the contrary. We feel therefore, that it is necessary to use a high temperature transfer media and we are recommending Hot Transfer Oil.

The danger of having the oil contaminate the water is eliminated through positioning in the system so that the exchanger is the last item before pump pressurizing. This means the system water being heated is a higher pressure than the oil, resulting in any leak to be from water to oil and corrections are made for same.

The attached E821J covers the items we include as a turn key proposal. The figure breakdown is an approximate relationship because we do not estimate under the specific items.

The total is however, correct and we would be prepared to take a turn key contract at the total figure shown of $4.43 MM at this time for completion in 1983.

Yours very truly,

C.G.Kerr,P.Eng.
K.C.I.Mechanical Inc.

CGK;jbk
encl.

ESTIMATE E821J - TUMBLER RIDGE, B.C. - BY C.G.KERR 1982

1 - Boilers (1920 M) suitable for hot oil transfer media with two twin packages with multi-fuel burners to give a total of 80 MM BTU/hr. when firing oil and solid fuel or gas and solid fuel. Preheat and clean-up to be light oil or gas. Main burner can be any grade of oil or gas. Solid fuel to be coal, garbage or wood. In addition two boiler packages would be provided for a capacity of 30 MM each to be fired with oil or gas. Oils can be light or heavy.

2 - Stack (70 M) Multi-flue insulated stack with automated damper control to keep velocity within accepted standards and to block off those not in use. This is both an Air Management assistance and of real benifit in keeping temperature and velocity to the desirable range. The height selected is 60 ft. and it would be self supporting with aid of building structure but without guy wires. Should some authority ask for additional height we would ask for an extra if over 90 feet.

3 - Boiler Feed (153 M) (Circulating) pumps, dump tank, make-up, trap tanks and heat exchangers with control. Dual exchangers have been calculated for assurance of continuity incase of one in trouble.

4 - Land Preparation (168 M) which includes clearing, grading, sumps, culverts for drainage, asphalting and sodding. This is based on access to the site by others with roadway suitable for floats and cranes.

5 - Duct (34 M) from boilers to stack insulated and erected and internally coated for acid protection.

6 - Electrical (83 M) Supply to site by others. Our work to include a transformer suitable for the electrical to be supplied in this contract. Balance of electrical with distribution panel and runs to individual unit disconnect.

7 - Material Handling (255 M) Main feed of coal garbage or refuse would be fed with an Auto crane unit which would also be used by an operator to level the pile or spread from the dump door area. A bobcat would also be supplied for back up to the automated crane in case of breakdown.

8 - Waste Disposal (63 M) A conveyor plus storage hopper to handle the ash and unburnables. A dump truck to remove refuse from the storage bin to a town dump is also to be part of this supply.

9 - Oil Handling (53 M) Two vertical storage tanks for Bunker plus one for light oil along with pumping and heating equipment, duplexed for stand by and automated for control.

10 - Low Pressure Gas Station (23 M) consisting of tank storage with handling components and fenced protected area.

11 - Building (334 M) prefabricated with insulated panels, to be suitable for components such as silo storage to ten day minimum, steel for craneway, multi door dump chutes, weight scales, control room, maintenance room, wash rooms etc.

12 - Installation and Engineering (1279 M) This is the completion of the turn key from drafting through freight, erection, lodgings, supervision, liason, approvals, testing, commissioning and operator training.

Canadian Content - All equipment in this quotation is to be a Canadian purchase. It would be beyond our control if their sub - suppliers in rare cases are an imported item.

British Columbia Content - The majority of equipment would have bids made from B.C. supply houses and it would be expected that the freight alone would make them competitive therefore, of British Columbia supply.

Jobsite Content - The estimate is made on the basis that the order would be direct and not through a jobsite contractor which also means that we are free to hire local labour without dictation from Unions.

Local Representative - Our area representative is Mr.K.N.Glover of Gowlland Pt. Rd., RR 1, Pendar Island, B.C. phone 629-6687. Ken prefers to pass on the normal selling call but his field experiences are most valuable from many years with Mechanical Contractors namely Foundation Co., Fraser Brace and Pentagon.

Field and Detail - With our Affiliated company Kermecho Ltd. we have a wide range of talents and experiences to draw from to expend on this potential work. Many of these contracts have been in the Alaska and Territory area.

Taxes have not been included as we believe there would be many parts if not all applicable for exemptions.

Approvals - All required Federal and Provincial approvals are considered a part of this turn key but we have not considered or included for any local level town or municipal levies or taxes.

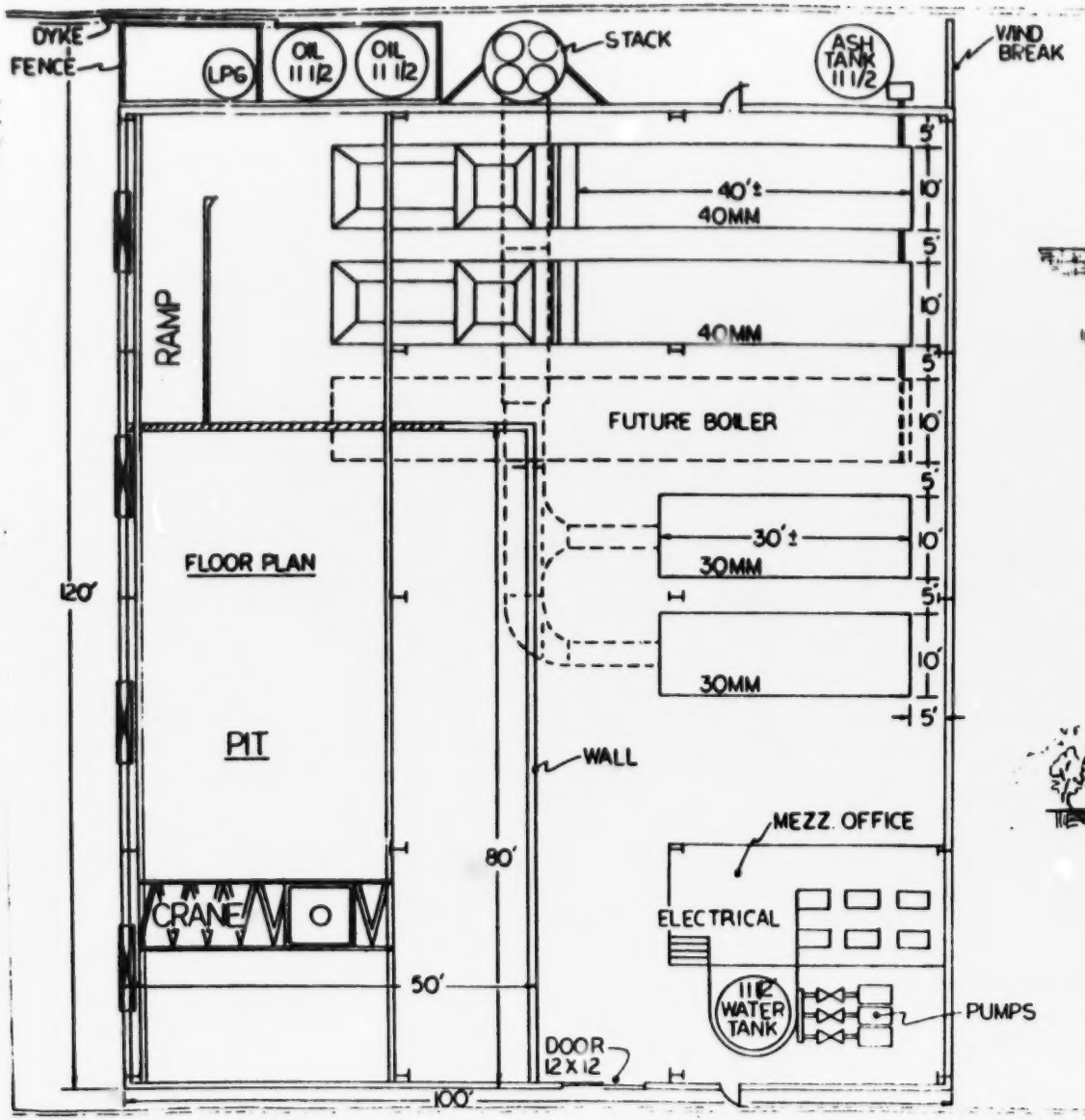
Automation - This design is for an Automated plant within the realm of all practical design.

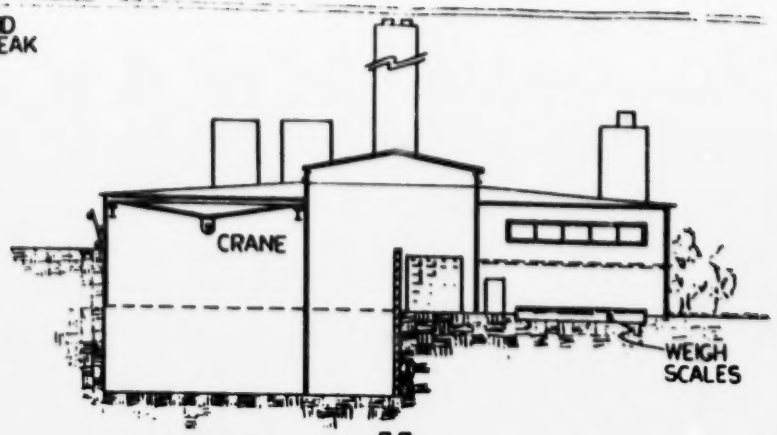
The laws as we read them and do in other places would mean that no licensed personnel would be required to be in attendance at any time Furthermore the plant would run with electronic monitoring where in failures would signal to the control room with memory annunciation plus telephone in sequence to four numbers when placed in this mode.

Timing - Considering that heat is required for September 1982 and that an order may not be placed until late March the timing is tight. It is highly probable that a delay after mid April would require temporary boilers which would be an added cost. Final completion would extend to mid 1983.

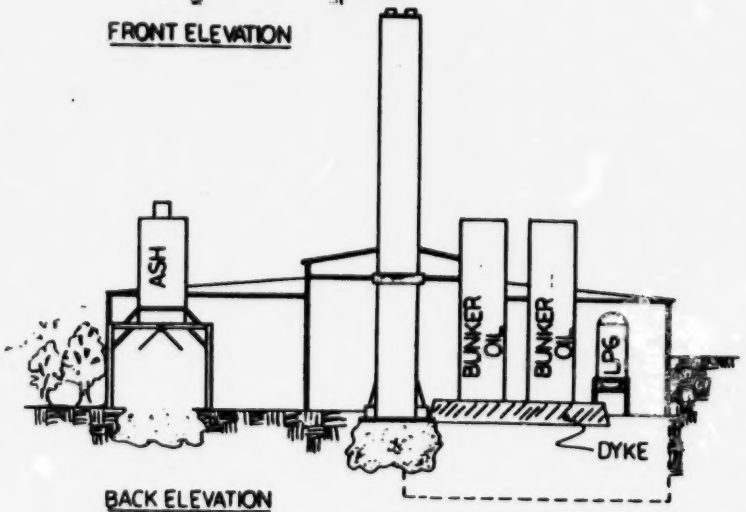
Garbage Note - Although we have stated above that city garbage could be fired the system would not allow large pieces such as stoves, tree stumps or similar oversized pieces without pre shredding.

The total price of above adds to.....$4.43 MM.





FRONT ELEVATION



BACK ELEVATION
1/2"

C. G. KERR
REGISTERED PROFESSIONAL ENGINEER
PROVINCE OF ONTARIO

TUMBLER RIDGE, B.C. - POWER PLANT

COGENERATION ASSOC. LTD.

KCI Mechanical Inc.

GENERAL ARRANGEMENT - PROPOSED

3/4" = 1'0"	JAN. 82	CGK / JBK	F83.01-1

POOR

QUALITY

ORIGINAL